Principles of Vaccination

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Immunity

- Self vs. nonself
- Protection from infectious disease
- Usually indicated by the presence of antibody
- Generally specific to a single organism

Immunity

- **Active Immunity**
  - Protection produced by the person's own immune system
  - Often lifetime
- **Passive Immunity**
  - Protection transferred from another animal or human
  - Effective protection that wanes over time

Antigen

- Live or inactivated substance (e.g., viruses and bacteria)
  - Capable of producing immune response
- Anti + gen = antibody generator

Antibody

- **Protein molecules (immunoglobulins)**
  - Produced by B cells (lymphocytes) to bind to a corresponding antigen (lock and key mechanism)
  - Helps neutralize antigen and prepare it for uptake and destruction by phagocytes
  - Bone marrow is site of B cell development

Arms of the Immune System

- **Humoral – antibodies**
  - Antibodies that can be used by the person who made them or transferred to a person who is not immune to temporarily protect that person against an invading antigen

Arms of the Immune System

- Cell-mediated – T lymphocytes and killer cells
  - Immune response that does not involve antibodies
  - Involves the activation of macrophages, natural killer cells, and antigen-specific cytotoxic T-lymphocytes, as well as the release of various cytokines in response to an antigen
  - Thymus is site of T-cell development

Passive Immunity

- Transfer of antibody produced by one human or animal to another
- Temporary protection that wanes with time
- Transplacental antibody most important source in infancy

PASSIVE IMMUNITY VIDEO

Sources of Passive Immunity

- Many types of blood or blood products
- Homologous pooled human antibody (immune globulin or IG)
  - IgG antibody from the blood of thousands of American adult donors
  - Hepatitis A and measles PEP

Sources of Passive Immunity

- Homologous human hyperimmune globulin (e.g., HBIG)
  - Taken from donors with high concentrations of a specific antibody
  - HBIG, RIG, TIG, VariZIG, VIG
- Heterologous hyperimmune serum
  - Antitoxin (e.g., diphtheria antitoxin)
  - Serum sickness

Monoclonal Antibody

- Derived from a single type, or clone, of antibody-producing cells (B cells)
  - Immune globulin from human sources is polyclonal (contains many different kinds of antibodies)
- Antibody is specific to a single antigen or closely related group of antigens
- Used for diagnosis and therapy of certain cancers and autoimmune and infectious diseases, as well as prevention of transplant rejection

Antibody for Prevention of RSV

- Palivizumab (Synagis)
  - Monoclonal
  - Contains only RSV antibody
  - Will not interfere with the response to a live virus vaccine

Active Immunity

- Protection produced by a person's own immune system
- Lasts for many years, often lifetime

ACTIVE IMMUNITY VIDEO

Sources of Active Immunity

- Infection with disease-causing form of organism
- Vaccination

Vaccination

- **Active immunity produced by vaccine**
  - Vaccine delivers a dead or attenuated (weakened, nonpathogenic) form of the pathogen
- **Immunity and immunologic memory similar to natural infection but without risk of disease**
  - Immunologic memory allows for an anamnestic response. After the primary immune response, the anamnestic response is reappearance of the antibody when the antigen is introduced

Factors that Affect Immune Response to Vaccines

- Presence of maternal antibodies
- Nature and amount of antigen in vaccine
- Route of administration
- Presence of an adjuvant
- Storage and handling of vaccine
- Vaccinee
  - Age
  - Nutritional status
  - Genetics
  - Co-existing disease

Classification of Vaccines

- Live attenuated
  - Viral
  - Bacterial
- Inactivated

Principles of Vaccination

General Rule: The more similar a vaccine is to the natural disease the better the immune response to the vaccine

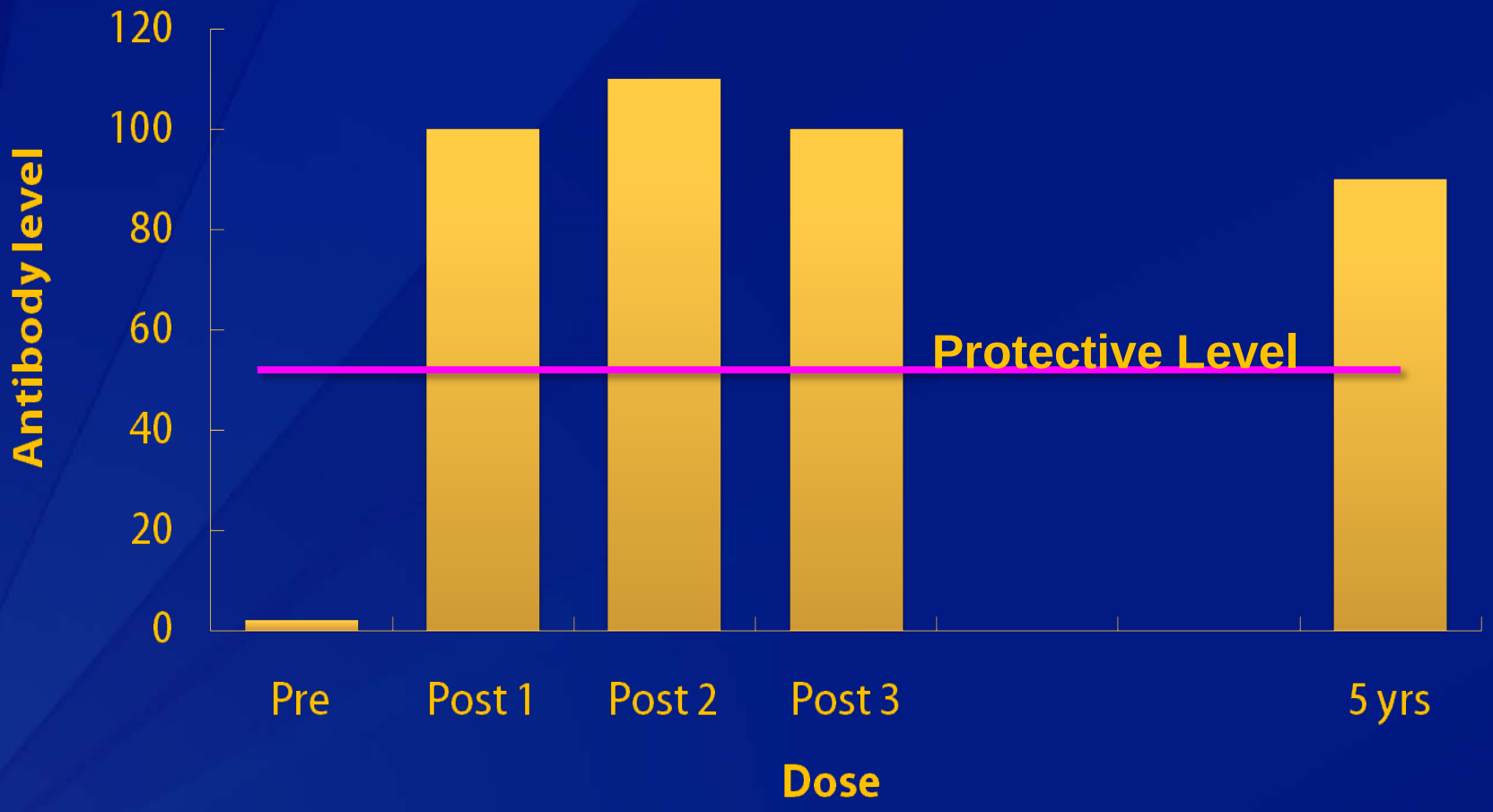
LIVE ATTENUATED VACCINES VIDEO

Live Attenuated Vaccines

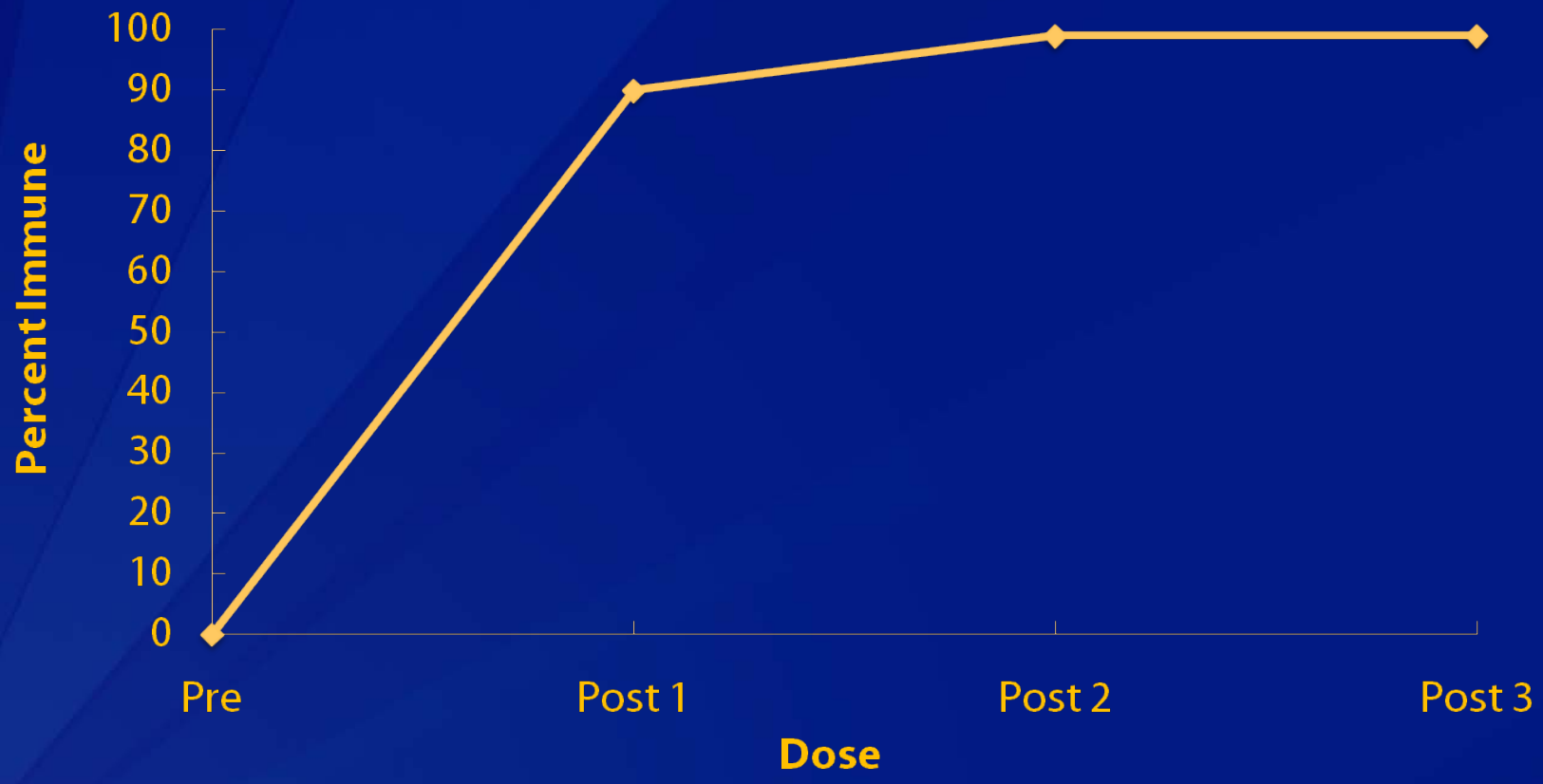
- Attenuated (weakened) form of the "wild" virus or bacterium
- Must replicate to produce an immune response
- Immune response virtually identical to natural infection
- Usually produce immunity with one dose*

*Except those administered orally

Individual Response to Live Vaccine

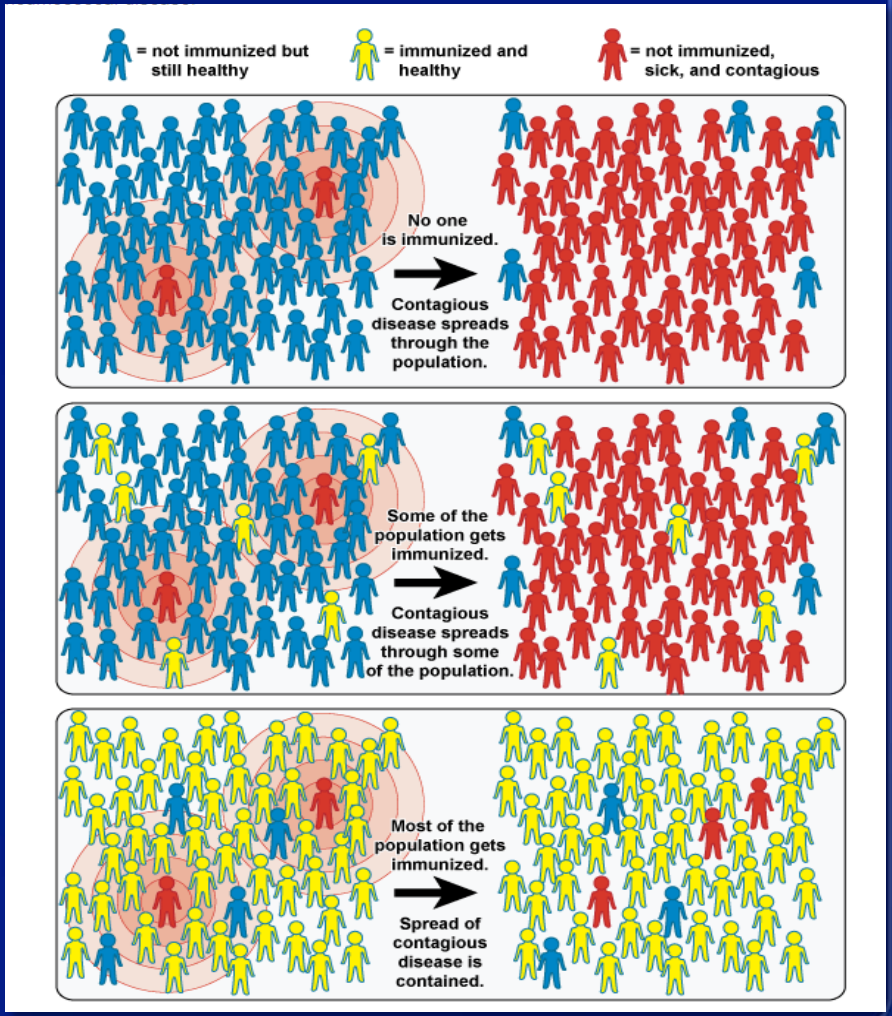


Population Response to Live Vaccine



Herd Immunity/ Community Immunity

- When a significant portion of the population is immune and provides protection for individuals who are not immune



Live Attenuated Vaccines

- Severe reactions possible
- Interference from circulating antibody
- Fragile – must be stored and handled carefully

Live Attenuated Vaccines

- **Viral** — measles, mumps, rubella, varicella, zoster, yellow fever, rotavirus, intranasal influenza, vaccinia, oral polio*
- **Bacterial** — BCG**, oral typhoid

*Not used in the United States

**Not used in the United States for routine TB protection

Inactivated Vaccines

Whole

- Viruses
- Bacteria

Fractional

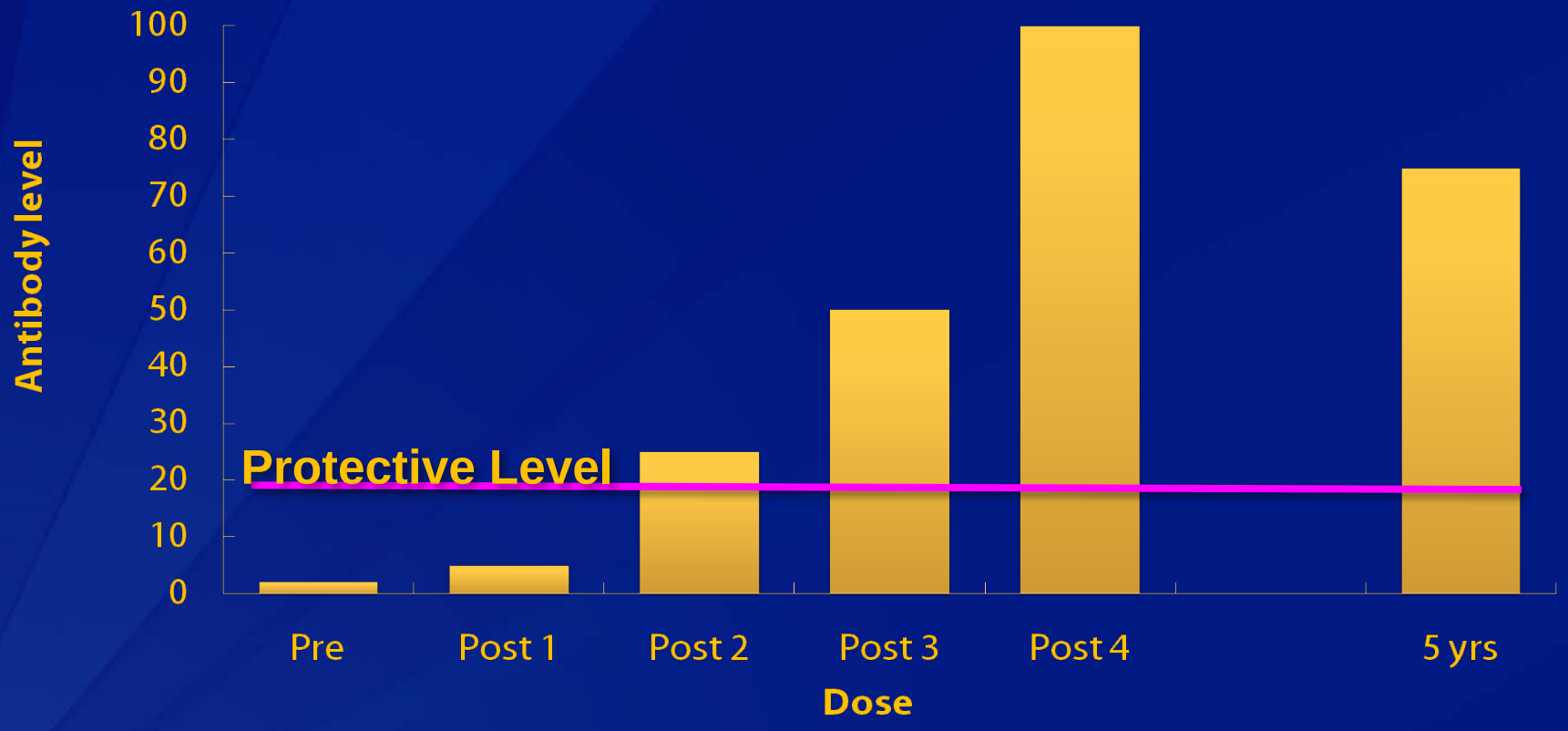
- Protein-based
  - Toxoid
  - Subunit
- Polysaccharide-based
  - Pure
  - Conjugate

INACTIVATED VACCINES VIDEO

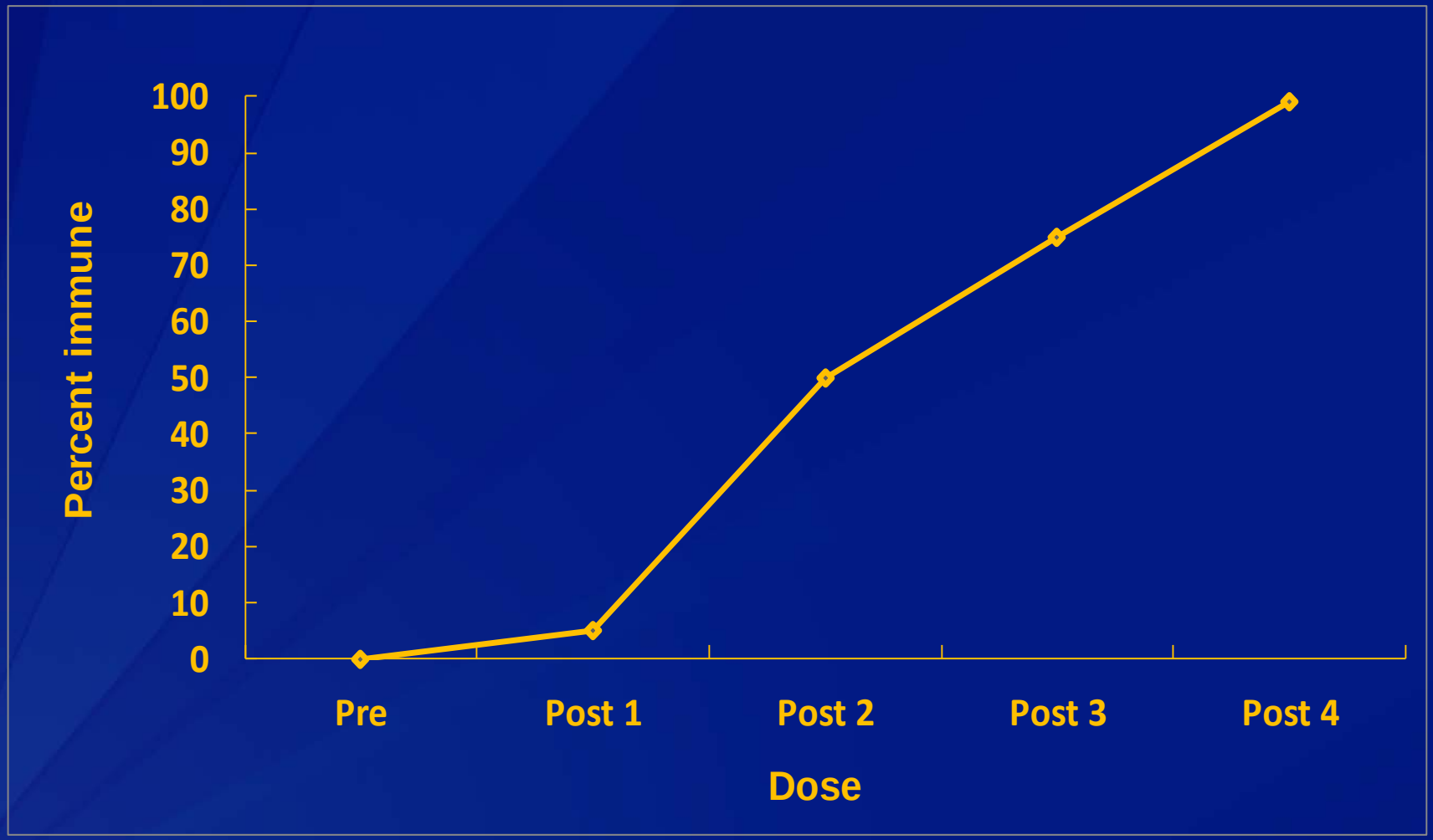
Inactivated Vaccines

- Cannot replicate
- Less affected by circulating antibody than live vaccines
  - Example: HepB vaccine and HBIG for perinatal hepatitis B PEP
- Always require multiple doses
- Immune response mostly humoral
- Antibody titer diminishes with time
- May require periodic supplemental booster doses

Individual Response to Inactivated Vaccine



Population Response to Inactivated Vaccine



Inactivated Vaccines

Whole

- **Viral** — polio , hepatitis A, rabies, influenza*
- **Bacterial** — pertussis*, typhoid*, cholera*, plague*

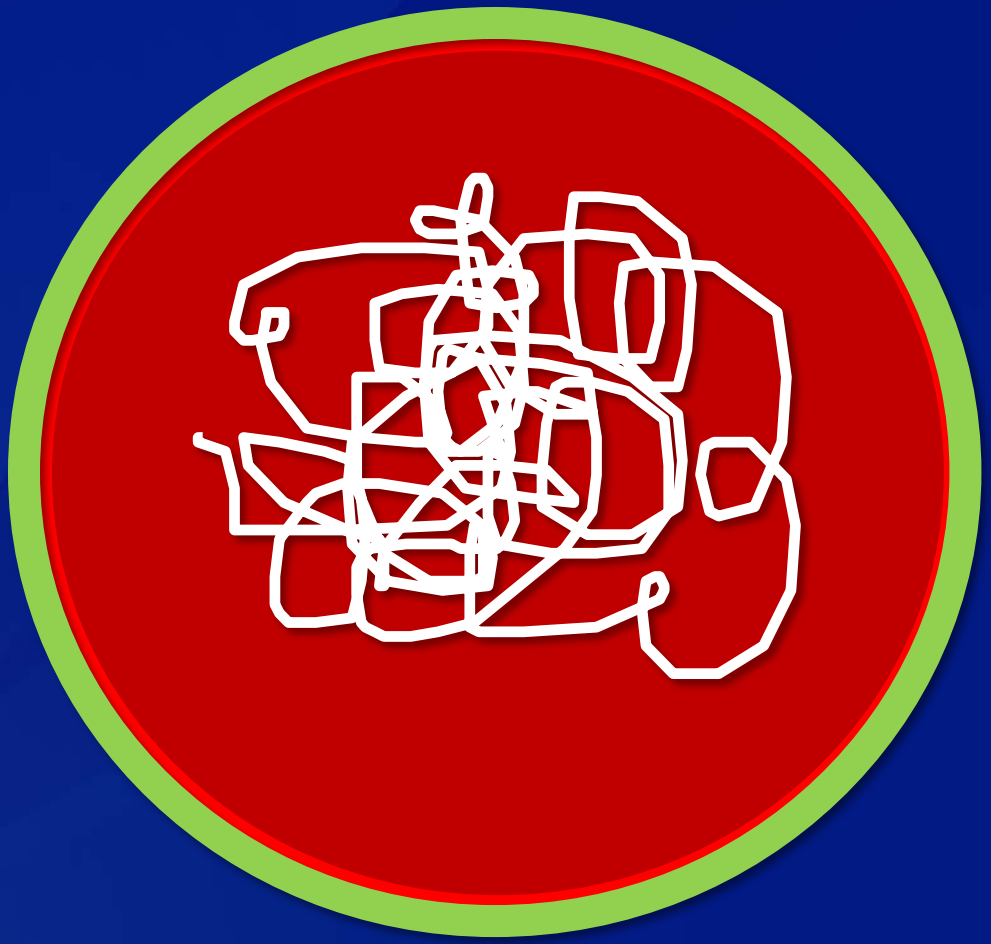
*Not available in the United States

Inactivated Vaccines

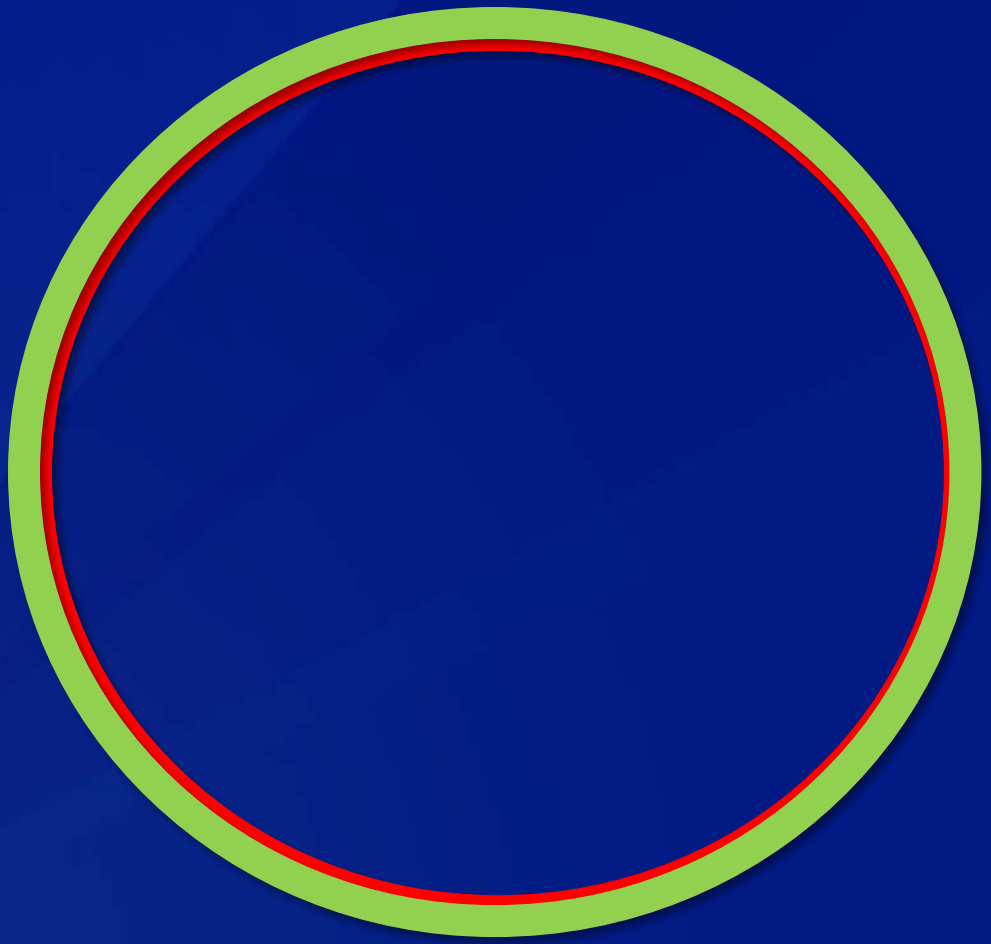
Fractional vaccines

- **Subunit** — hepatitis B, influenza, acellular pertussis, human papillomavirus, anthrax
- **Toxoid** — diphtheria, tetanus

Capsular Polysaccharide



Capsular Polysaccharide



Pure Polysaccharide Vaccines

- Immune response typically T-cell independent
- Not consistently immunogenic in children younger than 2 years of age
- No booster response
- Antibody with less functional activity (IgM rather than IgG)
- Immunogenicity improved by conjugation

Polysaccharide Vaccines

- **Pure polysaccharide**
  - Pneumococcal
  - Meningococcal
  - *Salmonella* Typhi (Vi)
- **Conjugate polysaccharide**
  - *Haemophilus influenzae* type b (Hib)
  - Pneumococcal
  - Meningococcal ACWY

Recombinant Vaccines

- Genetic engineering technology
  - Hepatitis B, human papillomavirus, and influenza (RIV3), and meningococcal B vaccines

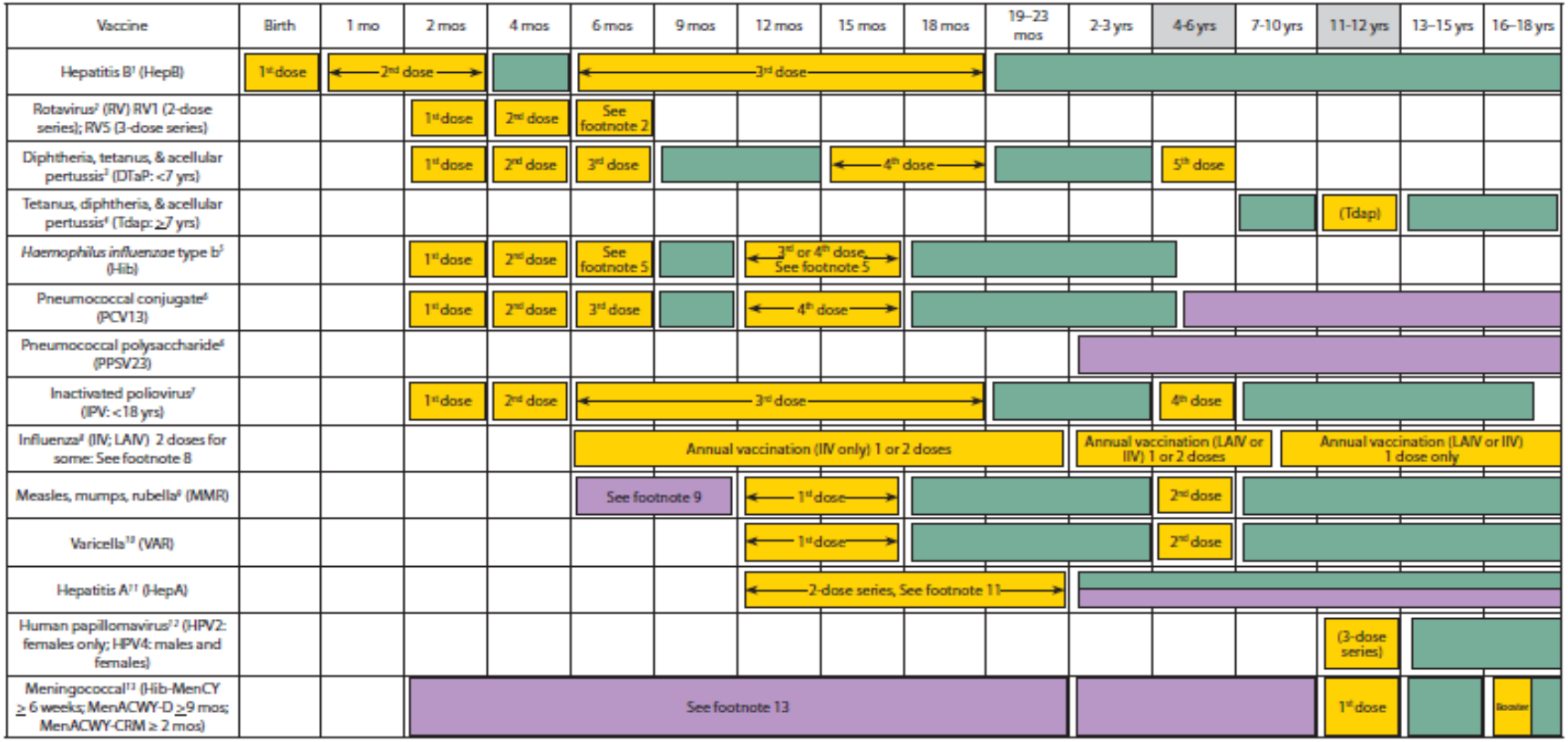
Reassortant Vaccines

- Reassortant vaccines are made by mixing genetic material from more than one source
  - Rotavirus (RV5)
  - Influenza (LAIV4)

Figure 1. Recommended immunization schedule for persons aged 0 through 18 years – United States, 2015.

(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are shaded.



Range of recommended ages for all children

Range of recommended ages for catch-up immunization

Range of recommended ages for certain high-risk groups

Range of recommended ages during which catch-up is encouraged and for certain high-risk groups

Not routinely recommended

This schedule includes recommendations in effect as of January 1, 2015. Any dose not administered at the recommended age should be administered at a subsequent visit, when indicated and feasible. The use of a combination vaccine generally is preferred over separate injections of its equivalent component vaccines. Vaccination providers should consult the relevant Advisory Committee on Immunization Practices (ACIP) statement for detailed recommendations, available online at http://www.cdc.gov/vaccines/hcp/acip-recs/index.html. Clinically significant adverse events that follow vaccination should be reported to the Vaccine Adverse Event Reporting System (VAERS) online (http://www.vaers.hhs.gov) or by telephone (800-822-7967). Suspected cases of vaccine-preventable diseases should be reported to the state or local health department. Additional information, including precautions and contraindications for vaccination, is available from CDC online (http://www.cdc.gov/vaccines/recs/vac-admin/contraindications.htm) or by telephone (800-CDC-INFO [800-232-4636]).

This schedule is approved by the Advisory Committee on Immunization Practices (http://www.cdc.gov/vaccines/acip), the American Academy of Pediatrics (http://www.aap.org), the American Academy of Family Physicians (http://www.aafp.org), and the American College of Obstetricians and Gynecologists (http://www.acog.org).

NOTE: The above recommendations must be read along with the footnotes of this schedule.

FIGURE 2. Catch-up immunization schedule for persons aged 4 months through 18 years who start late or who are more than 1 month behind — United States, 2015.

The figure below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. Always use this table in conjunction with Figure 1 and the footnotes that follow.

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to Dose 2	Dose 2 to Dose 3	Dose 3 to Dose 4	Dose 4 to Dose 5
Children age 4 months through 6 years					
Hepatitis B[1]	Birth	4 weeks	8 weeks and at least 16 weeks after first dose. Minimum age for the final dose is 24 weeks.		
Rotavirus[2]	6 weeks	4 weeks	4 weeks[2]		
Diphtheria, tetanus, and acellular pertussis[3]	6 weeks	4 weeks	4 weeks	6 months	6 months[3]
Haemophilus influenzae type b[4]	6 weeks	4 weeks if first dose was administered before the 1st birthday. 8 weeks (as final dose) if first dose was administered at age 12 through 14 months. No further doses needed if first dose was administered at age 15 months or older.	4 weeks[4] if current age is younger than 12 months **and** first dose was administered at younger than age 7 months, **and** at least 1 previous dose was PRP-T (ActHib, Pentacel) or unknown. 8 weeks and age 12 through 59 months (as final dose)[4] - if current age is younger than 12 months **and** first dose was administered at age 7 through 11 months; OR - if current age is 12 through 59 months **and** first dose was administered before the 1st birthday, **and** second dose administered at younger than 15 months; OR - if both doses were PRP-OMP (PedvaxHIB; Comvax) **and** were administered before the 1st birthday. No further doses needed if previous dose was administered at age 15 months or older.	8 weeks (as final dose) This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal[5]	6 weeks	4 weeks if first dose administered before the 1st birthday. 8 weeks (as final dose for healthy children) if first dose was administered at the 1st birthday or after. No further doses needed for healthy children if first dose administered at age 24 months or older.	4 weeks if current age is younger than 12 months and previous dose given at <7months old. 8 weeks (as final dose for healthy children) if previous dose given between 7-11 months (wait until at least 12 months old); OR if current age is 12 months or older and at least 1 dose was given before age 12 months. No further doses needed for healthy children if previous dose administered at age 24 months or older.	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age.	
Inactivated poliovirus[7]	6 weeks	4 weeks[7]	4 weeks[7]	6 months[7] (minimum age 4 years for final dose).	
Meningococcal[13]	6 weeks	8 weeks[13]	See footnote 13	See footnote 13	
Measles, mumps, rubella[8]	12 months	4 weeks			
Varicella[10]	12 months	3 months			
Hepatitis A[11]	12 months	6 months			
Children and adolescents age 7 through 18 years					
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis[3]	7 years[3]	4 weeks	4 weeks if first dose of DTaP/DT was administered before the 1st birthday. 6 months (as final dose) if first dose of DTaP/DT was administered at or after the 1st birthday.	6 months if first dose of DTaP/DT was administered before the 1st birthday.	
Human papillomavirus[12]	9 years	Routine dosing intervals are recommended.[12]			
Hepatitis A[11]	Not applicable (N/A)	6 months			
Hepatitis B[1]	N/A	4 weeks	8 weeks **and** at least 16 weeks after first dose.		
Inactivated poliovirus[7]	N/A	4 weeks	4 weeks[7]	6 months[7]	
Meningococcal[13]	N/A	8 weeks[13]			
Measles, mumps, rubella[8]	N/A	4 weeks			
Varicella[10]	N/A	3 months if younger than age 13 years. 4 weeks if age 13 years or older.			

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Recommended Adult Immunization Schedule—United States - 2015

Note: These recommendations must be read with the footnotes that follow containing number of doses, intervals between doses, and other important information.

Figure 1. Recommended adult immunization schedule, by vaccine and age group[1]

VACCINE ▼ / AGE GROUP ▶	19-21 years	22-26 years	27-49 years	50-59 years	60-64 years	≥ 65 years
Influenza*[,2]	1 dose annually					
Tetanus, diphtheria, pertussis (Td/Tdap)*[,3]	Substitute 1-time dose of Tdap for Td booster; then boost with Td every 10 yrs					
Varicella*[,4]	2 doses					
Human papillomavirus (HPV) Female*[,5]	3 doses					
Human papillomavirus (HPV) Male*[,5]	3 doses					
Zoster[6]					1 dose	
Measles, mumps, rubella (MMR)*[,7]	1 or 2 doses					
Pneumococcal 13-valent conjugate (PCV13)*[,8]	1-time dose					
Pneumococcal polysaccharide (PPSV23)[8]	1 or 2 doses					1 dose
Meningococcal*[,9]	1 or more doses					
Hepatitis A*[,10]	2 doses					
Hepatitis B*[,11]	3 doses					
Haemophilus influenzae type b (Hib)*[,12]	1 or 3 doses					

*Covered by the Vaccine Injury Compensation Program

- For all persons in this category who meet the age requirements and who lack documentation of vaccination or have no evidence of previous infection; zoster vaccine recommended regardless of prior episode of zoster
- Recommended if some other risk factor is present (e.g., on the basis of medical, occupational, lifestyle, or other indication)
- No recommendation

Report all clinically significant postvaccination reactions to the Vaccine Adverse Event Reporting System (VAERS). Reporting forms and instructions on filing a VAERS report are available at www.vaers.hhs.gov or by telephone, 800-822-7967.

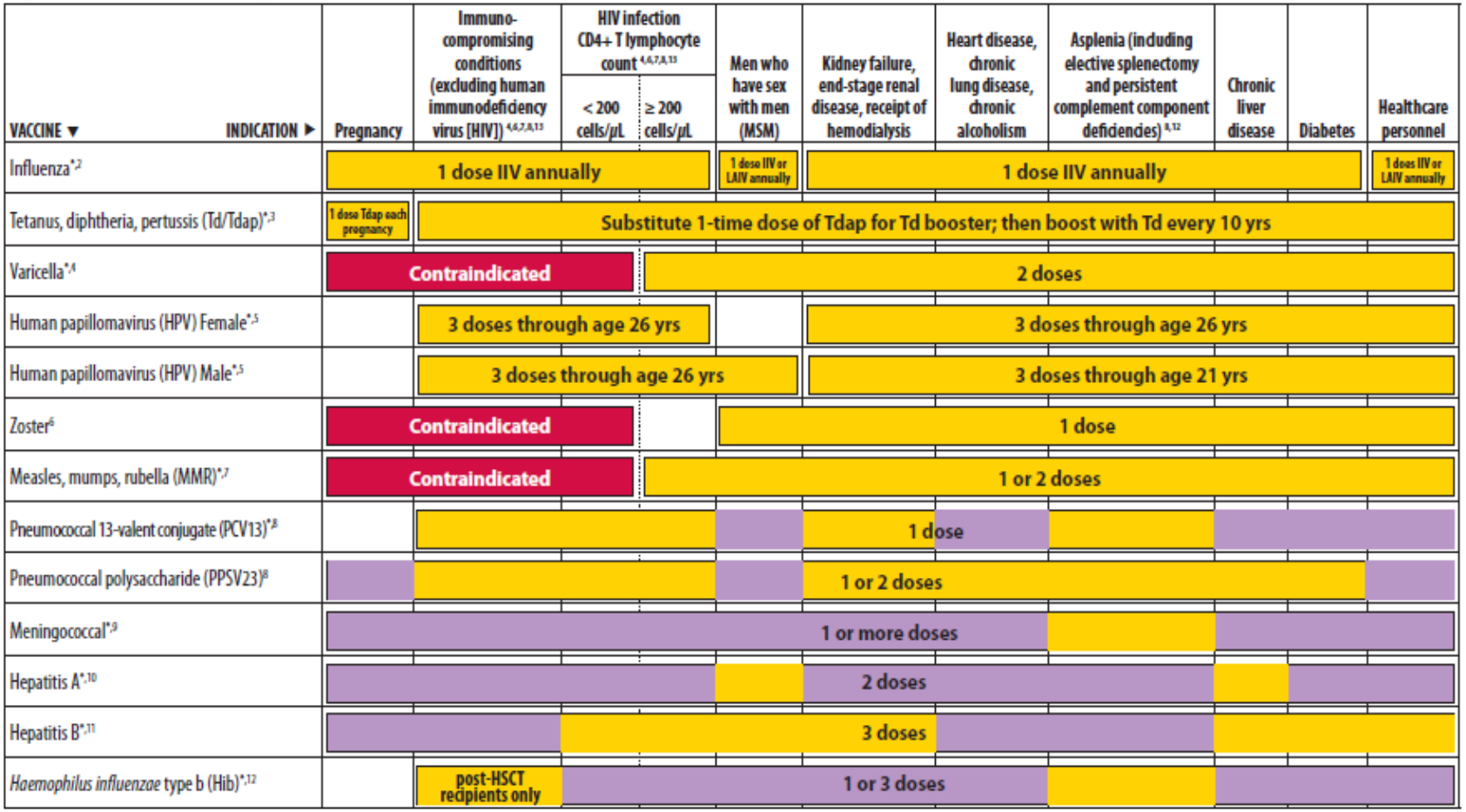
Information on how to file a Vaccine Injury Compensation Program claim is available at www.hrsa.gov/vaccinecompensation or by telephone, 800-338-2382. To file a claim for vaccine injury, contact the U.S. Court of Federal Claims, 717 Madison Place, N.W., Washington, D.C. 20005; telephone, 202-357-6400.

Additional information about the vaccines in this schedule, extent of available data, and contraindications for vaccination is also available at www.cdc.gov/vaccines or from the CDC-INFO Contact Center at 800-CDC-INFO (800-232-4636) in English and Spanish, 8:00 a.m. - 8:00 p.m. Eastern Time, Monday - Friday, excluding holidays.

Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

The recommendations in this schedule were approved by the Centers for Disease Control and Prevention's (CDC) Advisory Committee on Immunization Practices (ACIP), the American Academy of Family Physicians (AAFP), the America College of Physicians (ACP), American College of Obstetricians and Gynecologists (ACOG) and American College of Nurse-Midwives (ACNM).

Figure 2. Vaccines that might be indicated for adults based on medical and other indications[1]



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No recommendation

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

These schedules indicate the recommended age groups and medical indications for which administration of currently licensed vaccines is commonly recommended for adults ages 19 years and older, as of February 1, 2015. For all vaccines being recommended on the Adult Immunization Schedule: a vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Licensed combination vaccines may be used whenever any components of the combination are indicated and when the vaccine's other components are not contraindicated. For detailed recommendations on all vaccines, including those used primarily for travelers or that are issued during the year, consult the manufacturers' package inserts and the complete statements from the Advisory Committee on Immunization Practices (www.cdc.gov/vaccines/hcp/acip-recs/index.html). Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.